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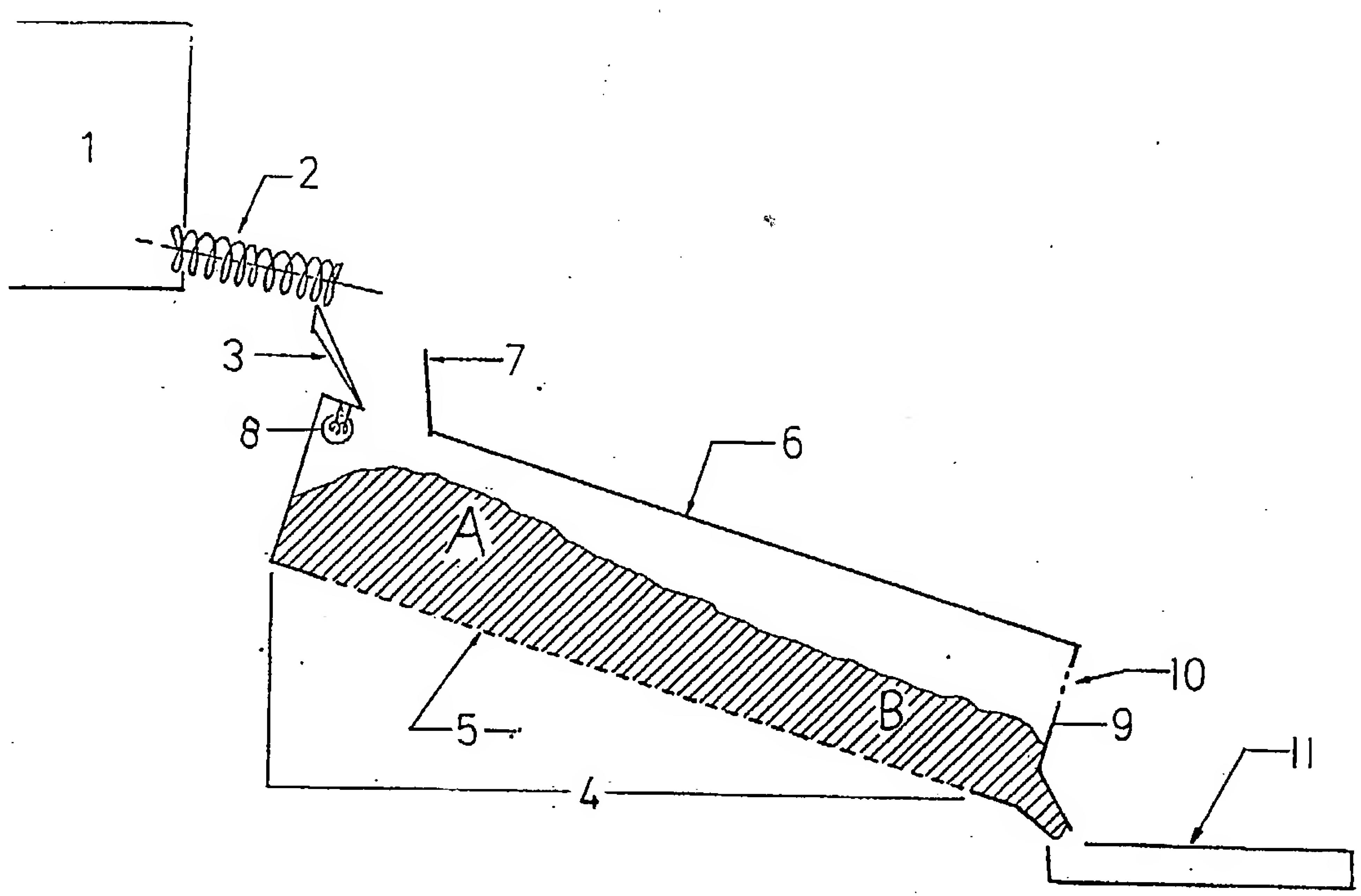
(54) **Rearing larvae**

(57) A method for the treatment of a solid material containing a protein, notably an animal waste slurry, comprises rearing larvae on a moving bed of the material on a trough 4, which bed passes through a series of zones A, B in which the bed is subjected to conditions of temperature and illumination which cause eggs on the bed to hatch adjacent to the upstream end A of the bed, to cause at least some of the resultant larvae to grow on the bed to the pupal stage in a downstream zone B of the bed and to cause at least some of the pupae to hatch and migrate to the upstream zone of the bed, attracted by light 8.



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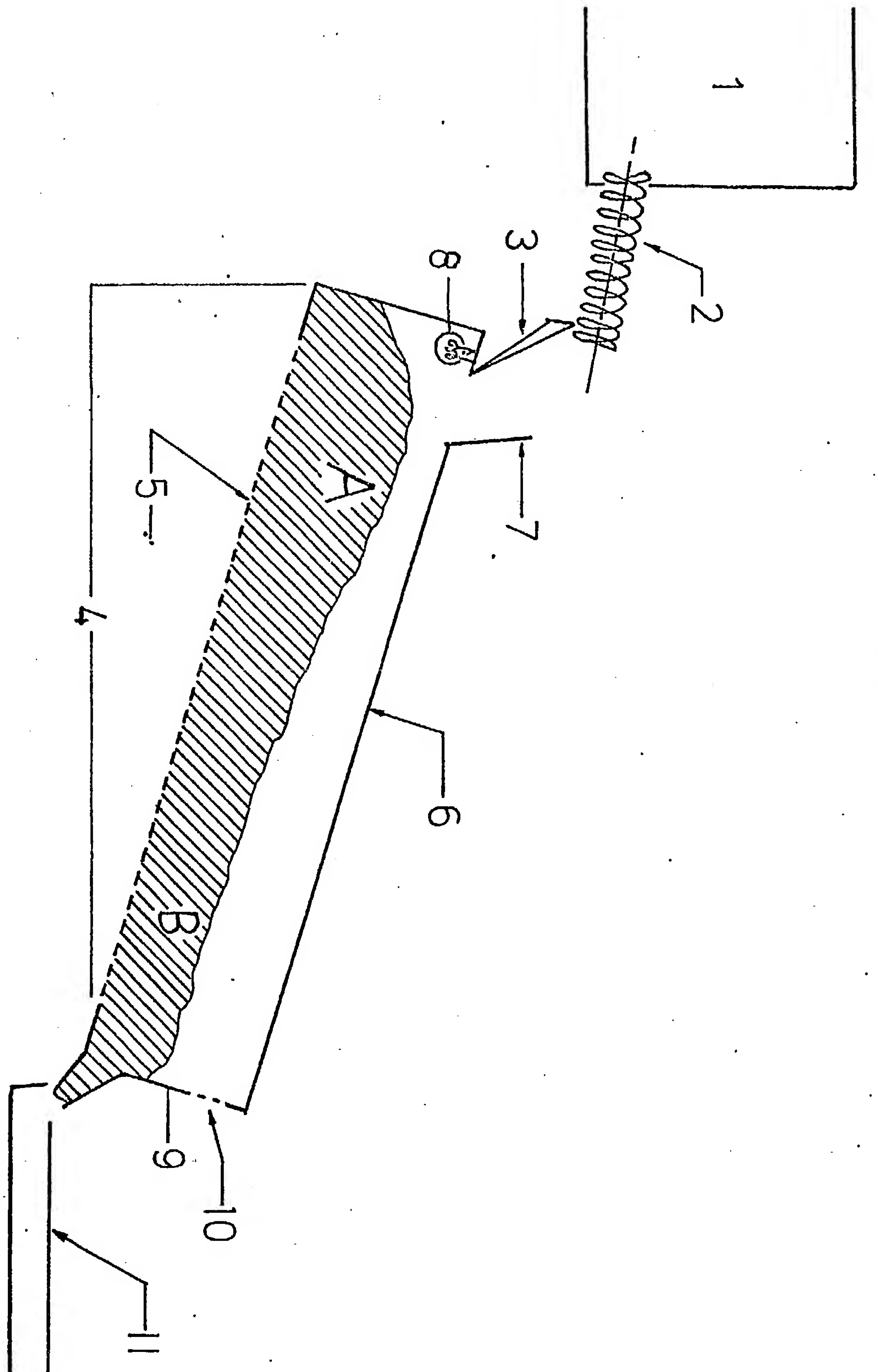

FIG. 1.

SPECIFICATION
Method of treating solid material

The present invention relates to a method for treating waste.

Proteinaceous waste is produced during a number of operations, e.g. as animal excreta from animal husbandry and as waste material from food processing or animal feedstuff production. This waste often occurs in larger amounts than can readily be handled by an operator and has an offensive smell. Also, it requires treatment before it can be disposed of, which can be an expensive operation.

We have now devised a method for treating a proteinaceous waste material which renders it fit for other uses and yields a valuable by-product.

Accordingly, the present invention provides a method for the treatment of a solid material containing a protein which method comprises rearing larvae on a moving bed of the material, which bed passes through a series of zones in which the bed is subjected to conditions of temperature and illumination which cause eggs on the bed to hatch adjacent to the upstream end of the bed, to cause at least some of the resultant larvae to grow on the bed to the pupal stage in a downstream zone of the bed and to cause at least some of the pupae to hatch and migrate to the first zone of the bed.

The method of the invention can be applied to a wide range of materials, e.g. to animal excrement from the rearing of pigs, cattle, poultry (notably chicken or turkeys), horses or rabbits; and to waste or reject material from making foodstuffs. It is preferred that, where an animal excrement slurry is used, it is in the form of a slurry of the larger particles, e.g. those with a largest dimension greater than 1 mm, preferably in the range 1 to 5 mms, which is used.

The material can be fed in the process of the invention in the form of a slurry of solid in a liquid carrier, in which case it is preferred that the solids content be at least 5%, preferably more than 12%, on a total weight basis. We have found that the churning action caused by the larvae in the bed of material assists separation of liquid phase from materials which have hitherto been difficult to separate, e.g. the gel-like material from an anaerobic digester for pig excrement. However, it is preferred to use the material in a friable fibrous or particulate form which can be readily handled and heaped. Thus, it may be desired to subject the initial form of the material, say rabbits pellets or horse dung, to maceration, optionally in the presence of water, to reduce to the optimum form for present use. It is also within the scope of the present invention to use a liquid proteinaceous material, e.g. a concentrated liquid effluent, which has been adsorbed and/or adsorbed onto a solid carrier medium, e.g. peat or a cereal meal or flake.

The material for present use contains a protein and this is preferably present in amounts in excess of about 10% dry weight. If desired, the material can be enriched with protein or other additives to ensure that the material provides an adequate growth medium for the larvae. The material can also be subjected to a pre-treatment, e.g. drying, maceration and/or aerobic or anaerobic digestion before it is used in the process of the invention.

Desirably, the material for present use has an initial water content of at least 40% on a dry weight basis, so as to provide humid conditions within and above the bed during at least the initial stages of the larval growth. However, it may be desired to allow or assist the material in the bed to dry out in the later stages of the method of the invention to promote pupation of the larvae.

In the method of the invention larvae are grown on the bed of material. During their growth, in general they reduce the bulk volume of the material and also offensive odours from the material are reduced. The resultant material is more acceptable for discharge to waste than the initial material and often finds use as a plant growth medium or soil conditioner. The method of the invention can be operated so as to produce predominantly larvae as a by-produce (which can be sold as such) or predominantly pupae which find use as a protein source, e.g. for animal foodstuffs. The method of the invention thus enables an unacceptable material to be processed to yield a usable product and to recover protein values therefrom. Whilst it can be applied to many types of larvae, the method of the invention is of especial use with the larvae of flies, notably of the common house fly (Musca domestica), meat flies (e.g. *Sircophoga* or *Caliphora vomitoria*) or fruit flies (*Borboridae*).

In the method of the invention a moving bed of the material is formed and this is passed through a series of zones of different illumination and temperature levels. The bed can be formed by feeding the material to a moving carrier surface, e.g. an endless conveyor belt or a moving platform; or by causing the bed to move along a stationary surface. Thus, material can be fed by gravity chute or auger to a moving belt moving in a trough or being provided with side walls to retain the load of material on the belt as it moves. Alternatively, the conveyor can be formed from a series of linked pans or containers. The moving carrier carries the bed of material through the various zones and discharges the treated material into a collection hopper. Howevever, we have found that a particularly simple method for forming the bed comprises feeding material to the upstream end of a trough. The movement of the bed along the trough is achieved in part by gravity where the trough is sloped, in part by the churning action of larvae within the material and in part by the forward movement imparted by feeding further material to the upstream end of the trough. If desired the trough can be inclined, e.g. at 5 to 25°, to the horizontal to aid movement of the material along the trough. In this way movement, of the bed of material is achieved without the input of significant amounts of energy and in a simple, cheap piece of equipment. However, if desired the trough can take the form of a tube or

drum which is rotated about its generally horizontal axis. In this way the bed of materials tumbles in the drum or tube, aiding aeration of the material and its movement down the drum. The trough can have any suitable cross section, e.g. semi-circular, triangular or squared. Also, if desired, the walls and/or base of the trough can be perforated to assist passage of air or other material through the bed and to aid release of excess moisture.

The bed passes through a series of zones which encourage eggs in the material to hatch, larvae to grow and pupate. It will usually be desired to subject the bed to an initial zone of high illumination, e.g. daylight or artificial illumination, to attract flies or other inserts arising from the hatching of pupae at a later stage to lay eggs on the material. If desired, the eggs can be introduced artificially. However, it is preferred to allow the egg laying to occur in situ, since this will enable the most suitable form of insect to establish itself in a given operation by natural selection.

After the initial light zone, the bed passes through a darker, warm, humid zone to promote hatching of the eggs and initial growth of the larvae. This zone is conveniently formed by covering the bed with a substantially light-proof lid, which preferably is thermally insulated. Thus, for example, the trough in which the bed lies is covered with a lid, the only light reaching the area under the lid being that from the illuminated first zone, e.g. that from the open feed port for the material or from the light source used in that zone. If desired, heat can be supplied to the bed, e.g. by using infra red lamps or by blowing warm air through the bed. Preferably, the heating is by indirect means, for example by using heating coils or cables in the wall of the trough. Desirably, the relative humidity of the atmosphere above the bed is maintained at 50 to 85% during the initial hatching and growth of the larvae. The temperature is preferably maintained at above 20°C, but at below the temperature at which the larvae sweat. This usually occurs at about 23 to 25°C. If desired, temperatures below 20°C can be used where it is desired to slow down the process, e.g. when there is a prolonged interruption in the supply of material to the bed.

The bed then passes to a zone wherein at least some of the larvae pupate and hatch. This is promoted by warm, drier conditions, e.g. by means of infra red lights or conventional lighting, or by ventilating the air space above the bed. Desirably, the moisture content of the bed is in the range 30 to 90% on a dry weight basis and the temperature is similar to that in the earlier zone, e.g. in excess of 20°C. At this stage the nutrient content and volume of the moving bed have been reduced due to the feeding action of the larvae. This would cause the larvae to move out of the bed in search of further food supplies. This movement can be channelled into a collection trough or other container. Alternatively, where the remaining bed is in an appropriate form and amount, the bed/larvae/pupae mixture can be discharged directly. If desired, the mixture can be separated by a suitable technique to recover the remaining bed material, e.g. for use as a mushroom compost.

As indicated above, the method of the invention can be operated to provide predominantly pupae in the end bed mixture or to provide predominantly larvae. The formation of pupae is achieved by a longer residence time of the larvae in the moving bed. This can be achieved either by a slower rate of movement of the bed through the same piece of equipment; or by lengthening the path of the moving bed, notably in the final zone of heat and light; or by a combination of these. Thus, in the case of the common house fly, it is preferred to have a total residence time of from 5 to 10 days for the moving bed to produce pupae and from a 2 to 7 days for larvae.

The optimum illumination, temperature and residence time conditions will depend upon a number of factors for each given case and the above description is given by way of a general guide.

The method of the invention is illustrated by the following Example which uses the apparatus shown diagrammatically in the accompanying drawing.

Solid chicken waste from an intensive battery unit 1 is fed by auger 2 to a chute 3 feeding an inclined trough 4. The trough has a truncated V cross-section and is inclined at 5° to the horizontal. The base of the trough can be provided with apertures 5 extending over the majority of the length of the trough. The apertures are typically 0.5 mms in diameter. The apertures enable excess moisture to drain out of the bed air to permeate through the bed. The waste enters trough 4 via an entry hatch 7 at the upper end of a cover 6 over the trough to form a bed in the trough. Typically, the waste has a protein content of 20% and a moisture content of 80%, both on a dry weight basis, and a temperature of about 5 to 15°C. The trough is of such a size that it can accommodate 7 days feed of waste from the battery unit 1. If necessary several troughs can be fed in parallel from one battery unit.

The walls of trough 4 are insulated to retain heat within the trough, e.g. with a foam plastics or mineral fibre cladding or Flectalon (shredded metal coated plastic sheet). Preferably, electrical heating cables are imbedded in the wall of the trough to provide indirect heating to the bed.

The upstream end of the trough is provided with a source of illumination to attract flies hatched at the lower end of the trough to lay eggs at the upstream end of the moving bed. This illumination can be provided by a light 8 or merely by opening the waste entry hatch 7. This latter also allows indigenous flies to lay eggs in the waste in the trough during the initial start up of the process.

The trough then has a zone of lower illumination (A) in which the warm humid conditions of the bed promote hatching of the eggs. The illumination in this zone is preferably provided merely by that spilling over from the first

zone. If desired low intensity lights, e.g. red or orange lights can be provided in this zone, to permit observation of the bed of material. A temperature of between 20 and 23°C is maintained by means of the heating cables in the trough wall. In some cases, e.g. during hot weather, it may be possible to dispense with the external heating once the operation of the bed has reached equilibrium conditions.

Movement of material down the trough is caused by the feed of new material to the trough and also by the movement of larvae within the material. This carries the waste/larvae mixture through zone A into zone B where the illumination is less intense than in zone A and preferably is provided by the overspill of illumination from the first zone. The temperature is maintained at 17 to 23°C to promote further growth of the larvae and cause pupation of at least some of the larvae. In, zone B drying of the bed of material occurs and this can be assisted by blowing air through or counter-current over the bed. Alternatively, the end wall of the trough can have an air inlet to permit a natural flow of air over the bed to the entry hatch at the other end of the trough.

Some of the pupae in zone B will hatch to give flies which are attracted to the light at the upper end of the trough to lay eggs there and thus start the cycle all over again.

The mixture from zone B is discharged onto a riddle or other separating device 10 in order to separate the larvae from the remainder of the bed material and these products collected for sale or use.

From another aspect, the invention also provides apparatus for use in the method of the invention which comprises a trough having its longitudinal axis inclined at from 5 to 25° to the horizontal, the trough having apertures in the base thereof, the side walls of the trough being thermally insulated and having means for indirectly heating the contents of the trough, the top of the trough being closed at least partially by an insulated cover which has an aperture at the upstream end thereof whereby material may be fed to the upper end of the trough, the trough being provided with means for circulating air over material in the trough.

CLAIMS

1. A method for the treatment of a solid material containing a protein which method comprises rearing larvae on a moving bed of the material, which bed passes through a series of zones in which the bed is subjected to conditions of temperature and illumination which cause eggs on the bed to hatch adjacent to the upstream end of the bed, to cause at least some of the resultant larvae to grow on the bed to the pupal stage in a downstream zone of the bed and to cause at least some of the pupae to hatch and migrate to the first zone of the bed.

2. A method as claimed in claim 1 wherein the bed is formed within an inclined trough to which material is fed at the uppermost end.

3. A method as claimed in claim 2 wherein the trough has insulated walls and a cover thereto, which cover has an opening at one end for feeding material into the trough.

4. A method as claimed in any one of the preceding claims wherein the bed of material passes through an initial zone of higher illumination, then through a darker zone in which the relative humidity of the airspace above the bed is in the range 50 to 85% and the temperature is maintained at from 20 to 25°C, then through a zone where the bed has a moisture content of from 30 to 90% on a dry weight basis, and the bed mixture is then discharged to a means for separating the larvae/pupae from the solid residue.

5. A method as claimed in any of the preceding claims wherein the material to be treated is a slurry containing at least 12% on a dry weight basis of solids.

6. A method as claimed in any of the preceding claims wherein the larvae and/or pupae are of one or more types of fly.

7. A method as claimed in any of the preceding claims wherein the material is chicken waste or a pig excrement slurry.

8. A method substantially as hereinbefore described.

9. Apparatus for use in the method of claim 1 which comprises a trough having its longitudinal axis inclined at from 5 to 25° to the horizontal, the trough having apertures in the base thereof, the side walls of the trough being thermally insulated and having means for indirectly heating the contents of the trough, the top of the trough being closed at least partially by an insulated cover which has an aperture at the upstream end thereof whereby material may be fed to the upper end of the trough, the trough being provided with means for circulating air over material in the trough.

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